A STUDY OF THE PREVALENCE AND DISPERSAL PATTERNS OF SEWAGE POLLUTION AT THE HONOLII SURFING AREA, HILO HAWAII. SUMMER 1989.

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INTRODUCTION

The Honolii surfing beach is located 3 miles north of Hilo Hawaii at the mouth of the Honolii Stream (see figure # 1). It is a highly used recreational area and is the most popular surfing beach in the Hilo vicinity. This area has been studied as a part of an ongoing study of sewage pollution in Hilo Bay and was found to have chronic water quality problems at the Honolii Stream mouth that empties into the cove. After reviewing the previous data it was felt that a more direct effort to determine the pollution concentrations and distribution patterns within the surfing area should be initiated.

This study was set up to gather water samples from seven sites in Honolii Cove, starting at the stream mouth and moving into the surfing area (see fig. #2 for stations). The stations were selected to cover areas both within and outside of the surf zone to see if a plume of pollution could be detected and if levels of bacteria changed as the stream emptied into the cove. Water samples were gathered offshore with the University of Hawaii research vessel Ka'imi Na'auao, in the surf zone with a surfboard launched from the vessel, and from the river mouth by land based technicians. The sampling regime covered seven days during a period from May 24 through July 17, 1989.

Figure #1, Site Location

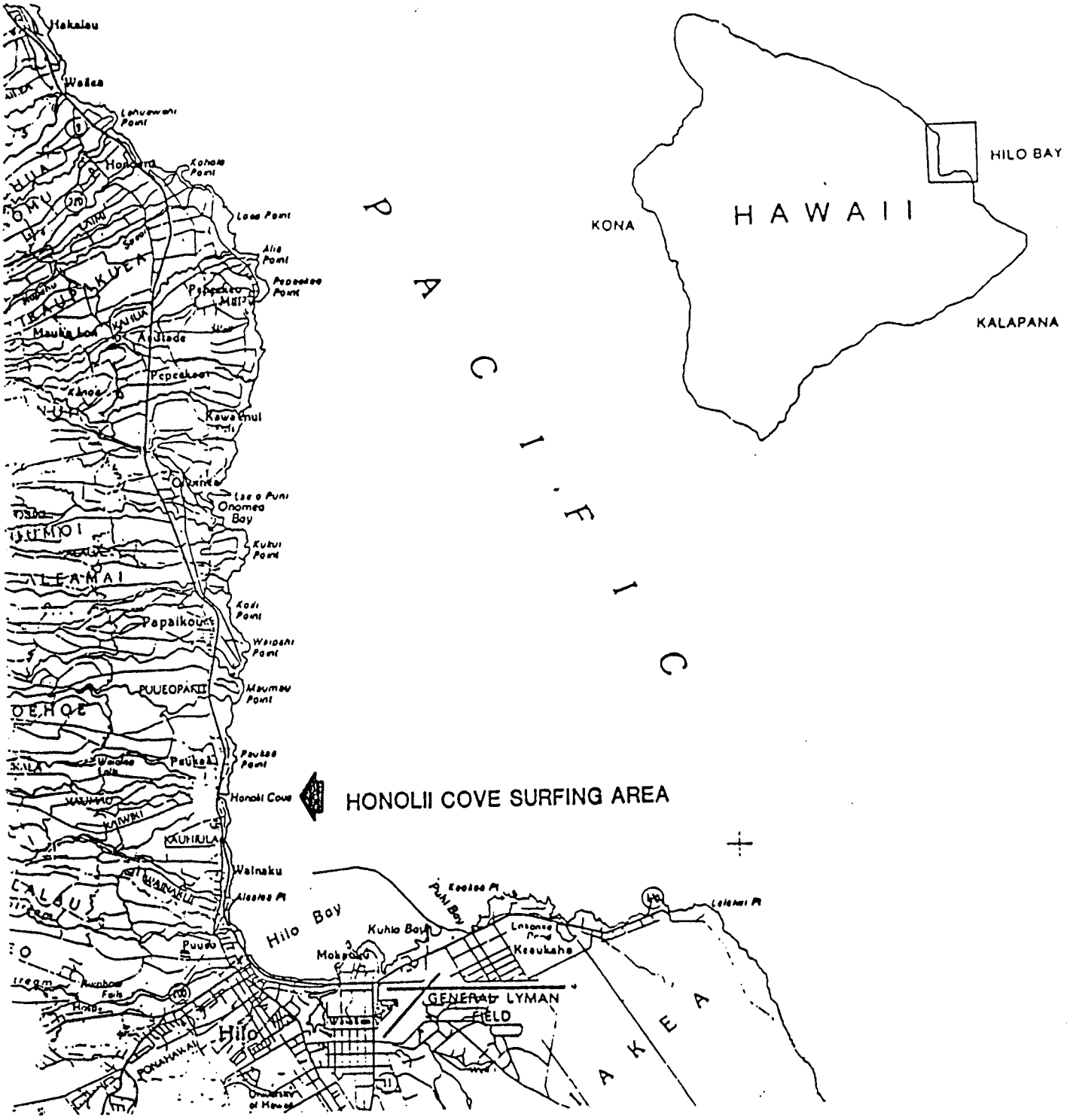
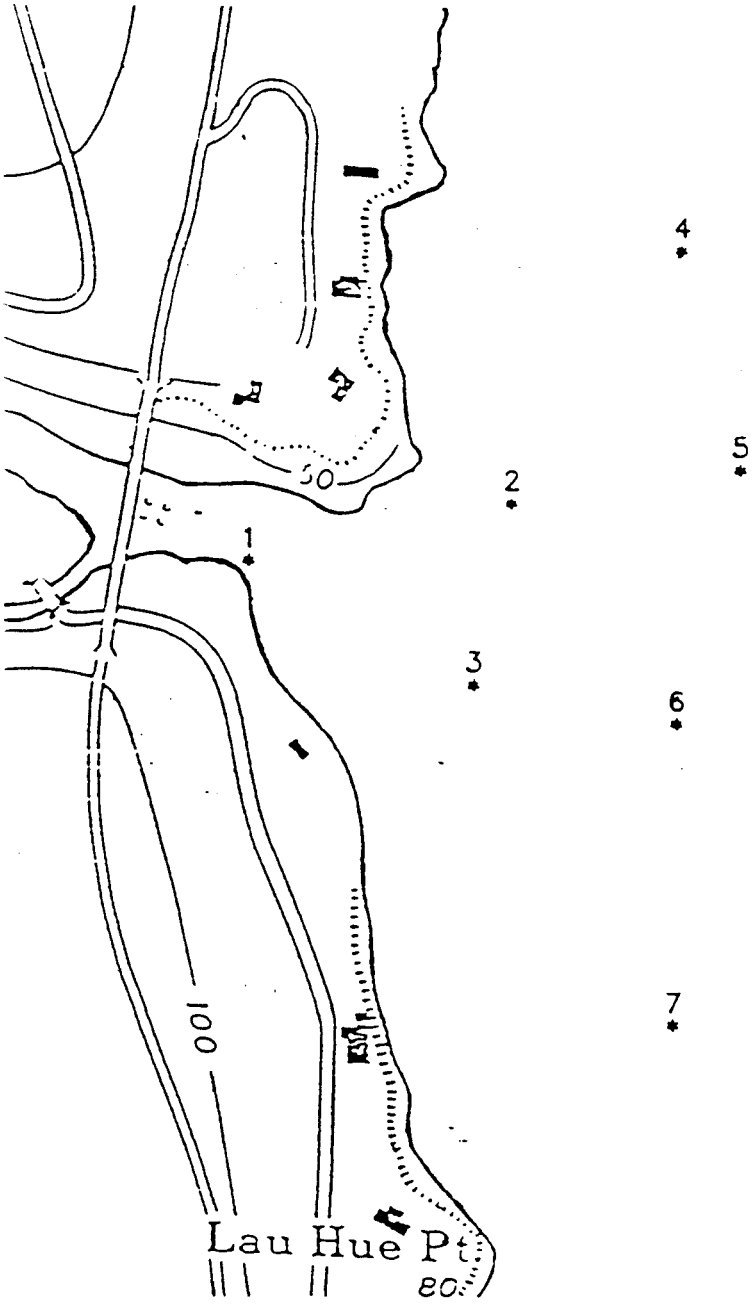


Figure #2, Station Map

Honolii River and Surfing Area Sampling Stations



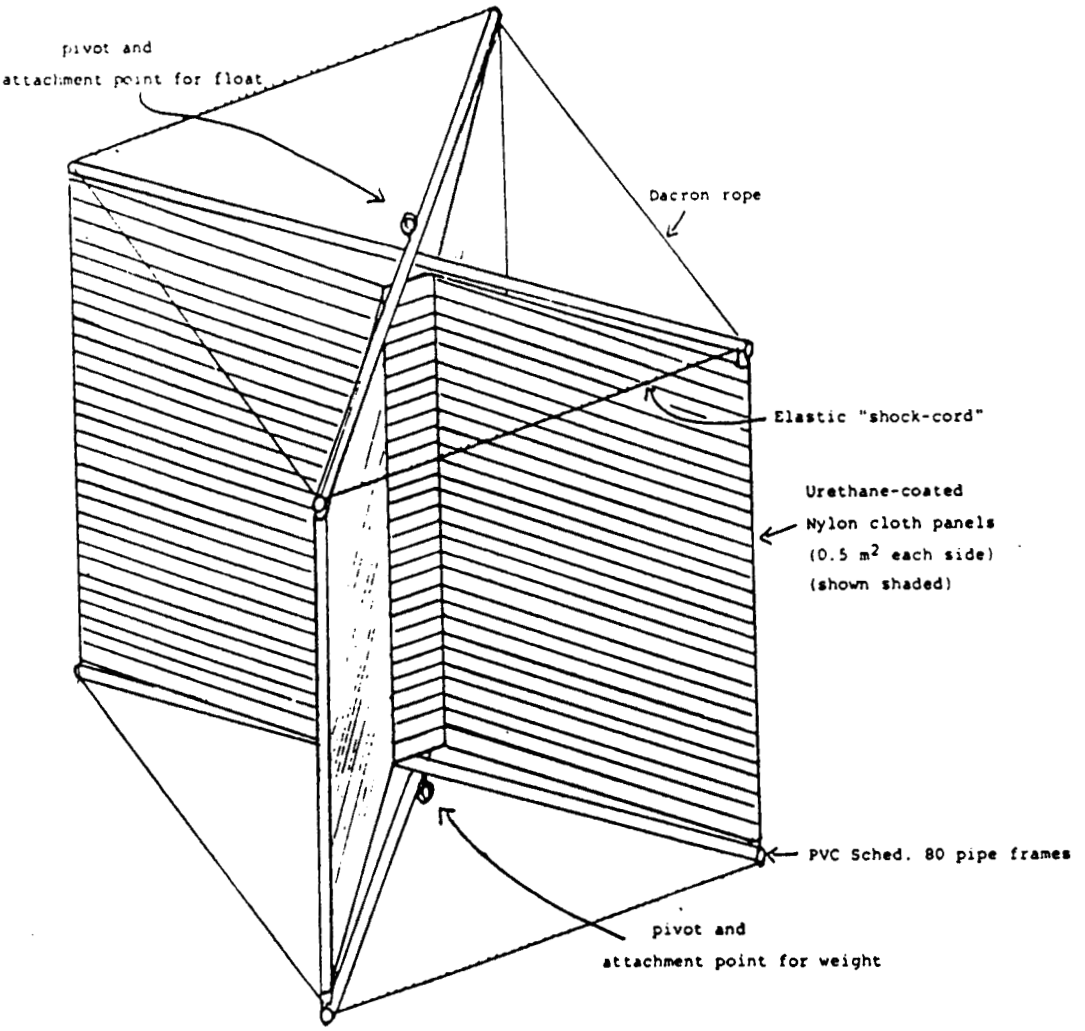
MATERIALS AND METHODS

All water samples were evaluated in accordance with the methods outlined in, STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTE WATER 16TH EDITION , using the Millipore Filtration technique. Samples were collected in sterile Nalgene bottles, placed on ice and returned to the University of Hawaii Minorities Biomedical Research Support (M.B.R.S.) program laboratory for filtration. As the samples were collected, additional environmental data was gathered from each site. Temperature, salinity, pH, dissolved oxygen concentration, tide, and wind speed and direction information were all entered on data sheets. Previous 24 hr. rainfall data was also added after local weather reporting agencies provided the information. The salinity measurements were taken with a Yellow Springs Instrument Co. (Y.S.I.), model 33 salinometer, and dissolved oxygen concentration is measured with a Y.S.I. model 57 dissolved oxygen meter. Offshore sampling was accomplished through the use of the research vessel, a 19' Larson fiberglass hulled runabout, Ka'imi Na'auao. A 9'6" Slick Hawaii surfboard is carried on board Ka'imi Na'auao for sampling within the surf zone. Two Coded Communications Corporation model HJAG5 walkie-talkies were used to coordinate sampling operations between shoreline and offshore technicians. Drogues used to track current were also deployed from the research vessel. These unique folding devices were fabricated by Mr. Tom Hammond, an oceanography instructor at

Hawaii Community College. These "Hammond Collapsible Drogues" were each equipped with RF 700 series radio location beacons (see figure #3). These beacons are used in conjunction with an L-Tronics LH series portable direction finder that could be used to home in on the beacon signals from long distance or in periods of poor visibility. In addition to the surface drogues an Aandera RCM-7 recording current meter was deployed at depth (2-3m) to monitor subsurface current speed and direction.

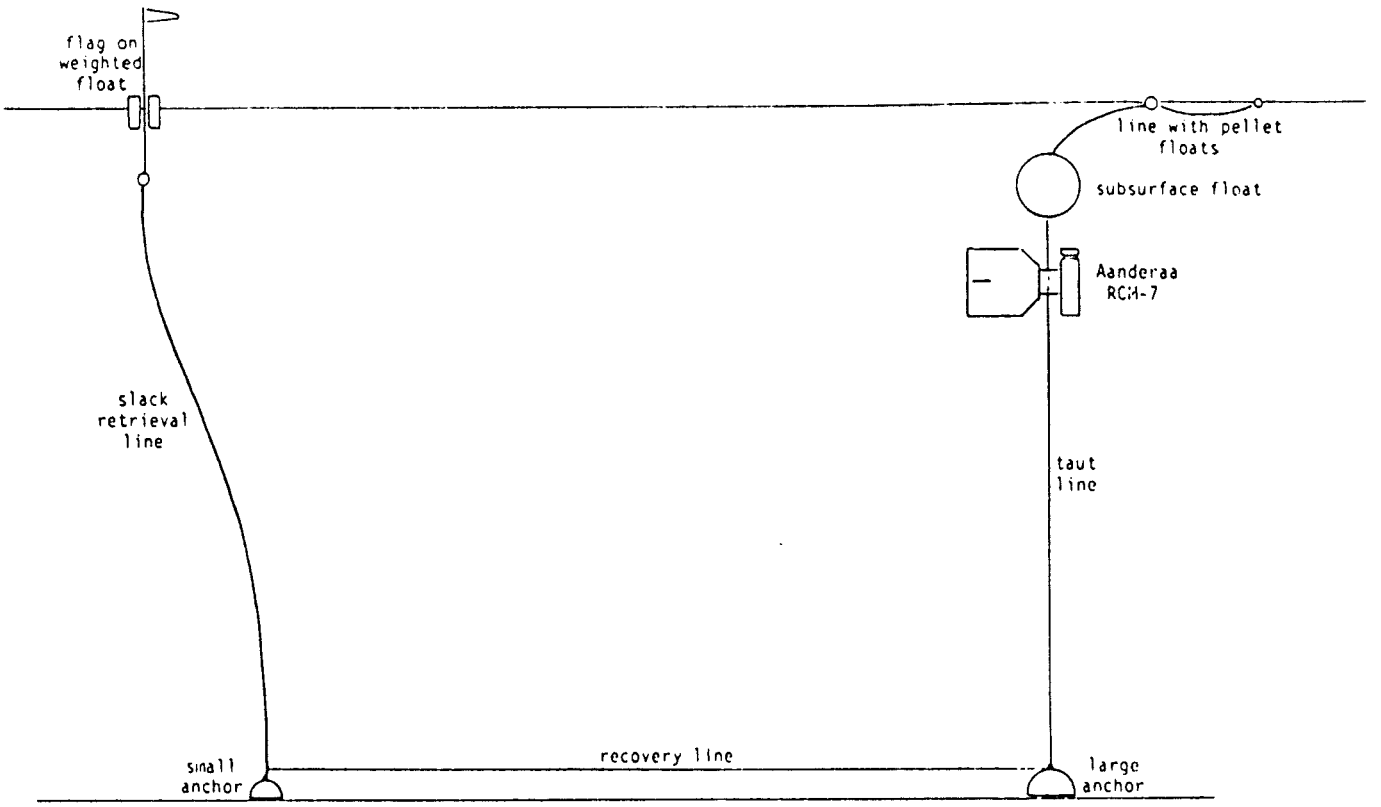
At Honolii the seven station survey was carried out using two teams of technicians, one team on shore and another offshore in the research vessel. The research vessel was launched from Hilo Harbor loaded with the necessary equipment and then proceeded to the Honolii station. Just offshore to the south and north of the cove drogues were deployed. Another drogue was deployed outside of the river mouth between those previously released. The positions of these devices was recorded using sightings on known buoys, lights, and towers that were periodically rechecked to monitor direction and rate of travel. After drogues were deployed the RCM-7 current meter was anchored in position and began recording surface current speed and direction (see figure #4 current meter deployment).

Figure #3, Drogue Detail



OBLIQUE VIEW OF DROGUE CONSTRUCTION

Figure #4, Current Meter Deployment



The water sampling at Honolii Cove was initiated by radio communication to the shoreline team. As soon as the shoreline team began their operations the surfboard was launched from the vessel to gather samples in the surfing area. This facilitated a near simultaneous collection of samples for later comparison. The surf zone technician returns the pre-labeled bottles for each of the four surfing area sites to the vessel. Salinity measurements are taken for these samples at that time. Other measurements cannot be taken in the surf zone because of obvious risks to equipment and personnel. While the surf zone and shoreline portions of the sampling were being carried out the research vessel gathered water samples and data from the remaining three offshore stations. All samples were placed on ice and returned to the M.B.R.S. program laboratory for filtration via the Millipore technique.

Two bacteria were selected as indicators of sewage pollution, fecal coliform (Escherichia coli) and fecal strep (Streptococcus fecalis). The bacteria were isolated by filtering two 50 ml. and two 5 ml. replicates of sample water diluted in sterile distilled water. The sterile distilled water allows for better dispersal of colonies across the filter membrane.

Fecal coliforms are one of the indicator organisms recommended by the Environmental Protection Agency to evaluate water quality from the standpoint of sewage pollution. Fecal coliforms are associated with the digestive tracts of warm blooded animals and are presently the most widely used indicator

organisms. Fecal coliforms were cultured in paraffin sealed petri dishes on Gelman certified M-FC broth in a water bath incubator at 44.5 degrees centigrade for 24 hours. Fecal strep are also bacteria specific to the intestinal tracts of mammals and are valuable indicators of pollution when used in combination with fecal coliforms. Fecal strep were cultured in petri dishes on ME agar at 45 degrees centigrade for 48 hours. After incubation the colonies were counted and numbers recorded on the data sheets. All data gathered was then entered into computers for later analysis.

RESULTS

During the seven day collection period fecal coliform and fecal strep densities were highest at station # 1, at the mouth of Honolii Stream (see station map figure #2). Higher bacterial densities in this study were directly correlated to higher previous 24-hour rainfall events (see figure #5, fecal coliforms and previous 24-hour rainfall). Only fecal coliform densities are shown on the maps.

During the Honolii study fecal coliform bacteria densities (number of colonies per 100 ml.) and salinity (parts per thousand) were selected as indicators of the relative movement of pollution into the surfing area. Bacteria densities were always highest at station #1 in brackish water (< 5 ppt salinity). From the stream mouth into the cove the current took a southerly turn and proceeded along the coast directly through station #2 and near station #7. This direction was illustrated on May 24 where coliforms ranged from 50 at station #1 and were diluted to approximately 20 at stations 3 and 7 (see figure # 6). On June 1 the coliform densities at station 1 reached 500 colonies and as the stream moved into the cove and to the south through stations 3 and 7 the levels dropped to 225 and >100 respectively. On that day station 6 was also within the plume between the 100 and 150 "isofecal" lines (see figure # 7). Salinity values were not available on these days due to salinometer malfunction.

Figure #5, Fecal Coliforms and Previous 24 Rainfall

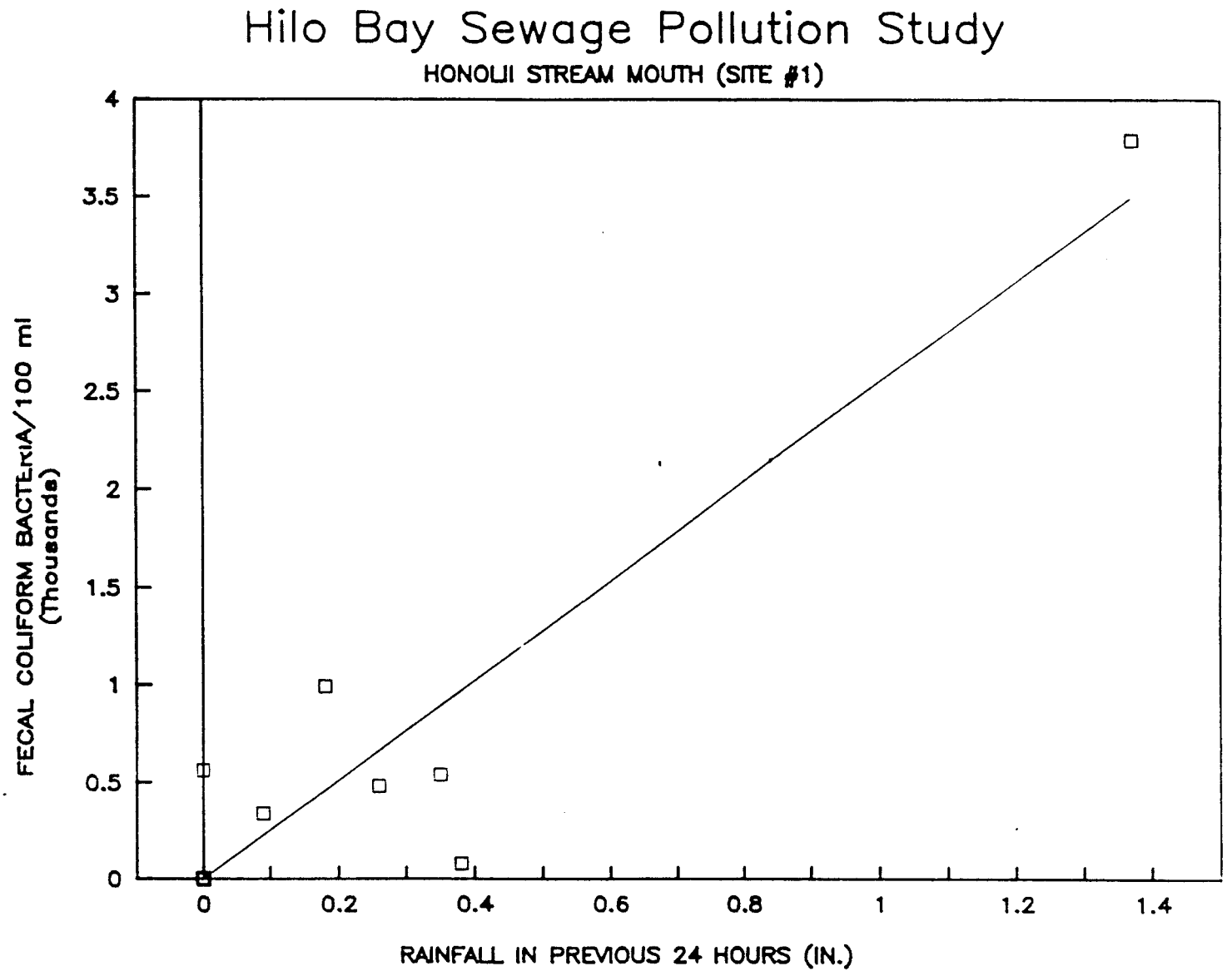
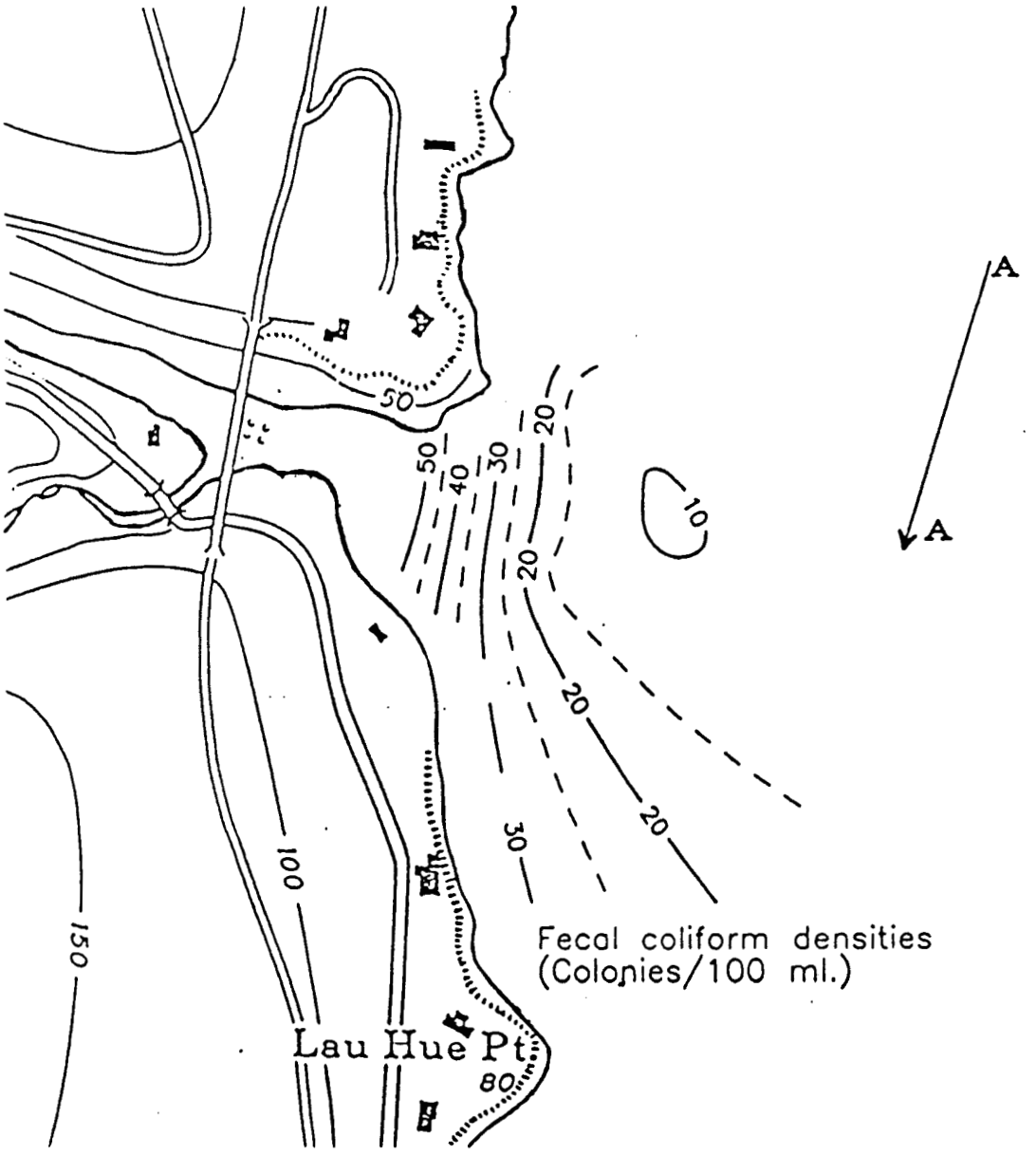


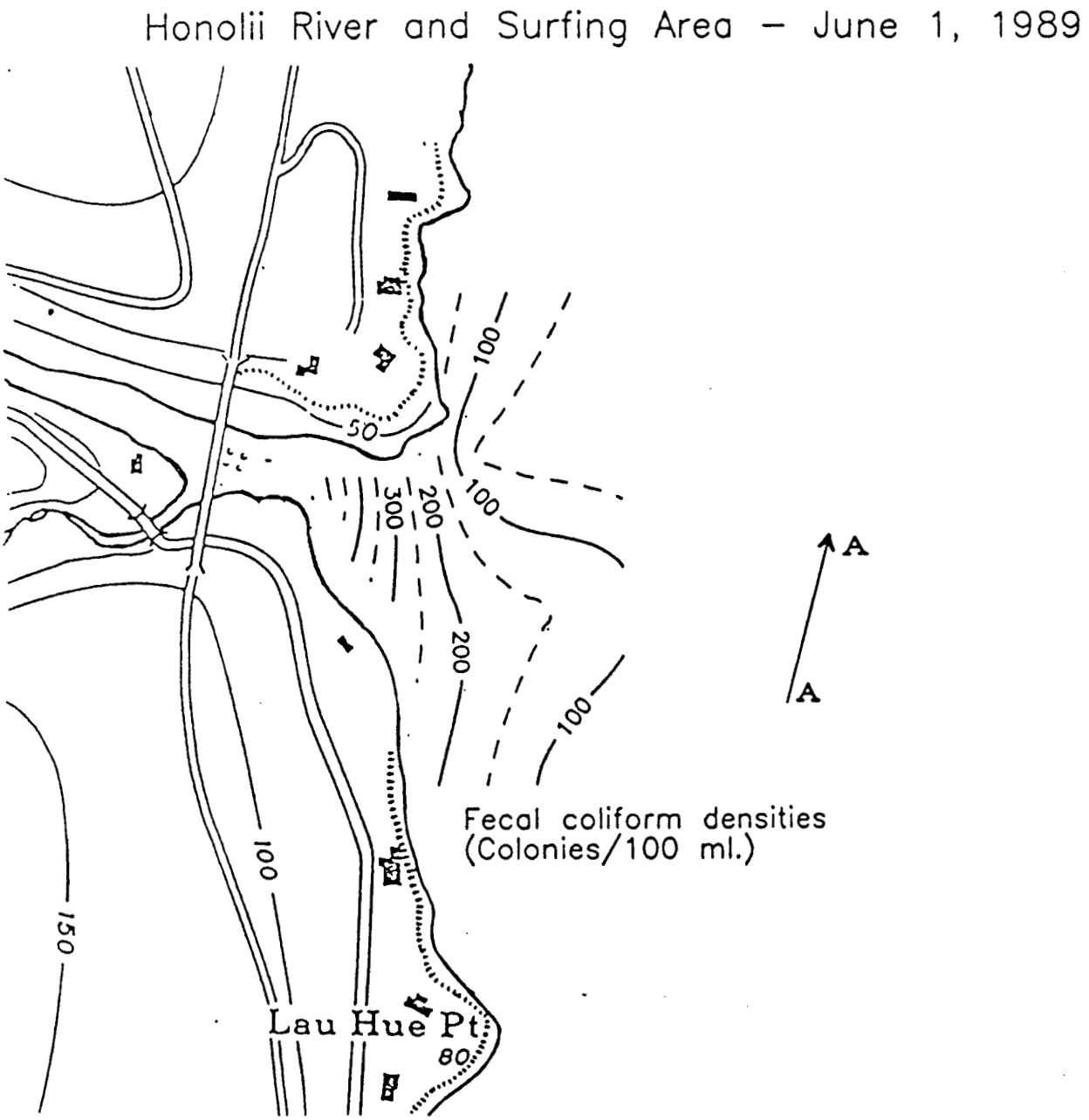
Figure #6

Honolii River and Surfing Area – May 24, 1989



Map of Honolii Beach Park showing fecal coliform bacterial densities for May 24, 1989. Densities are contoured on a contour interval of 5 colonies. The track of surface drogue "A" is also shown.

Figure #7

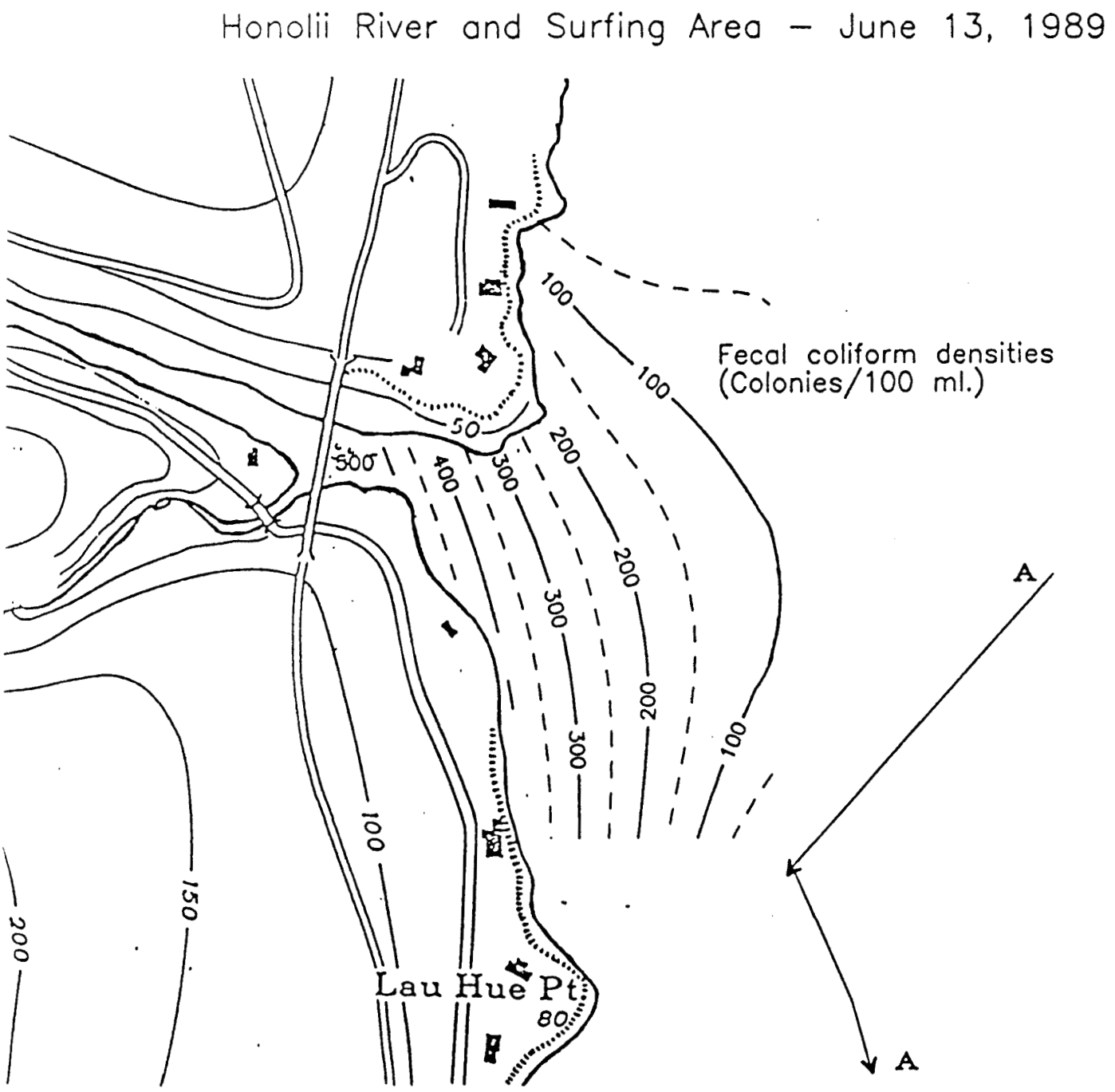


Map of Honolii Beach Park showing fecal coliform bacterial densities for June 1, 1989. Densities are contoured on a contour interval of 50 colonies. The track of surface drogue "A" is also shown.

The pattern was similar on June 13 where station # 1 levels were 500 colonies per 100 ml. and the densities tapered off as the current moved south toward Hilo. The salinity values slowly increased as this current moved along the shoreline 4 ppt. to 12 ppt.as the current swung by station # 7 (see figures # 8 and 9). On July 5, coliform densities at station # 1 reached 3600 colonies. As the stream entered the cove the highest coliform densities were found at all stations for the study period. Salinity values ranged from 4 ppt. at the river mouth to 12 ppt. at station #7 to the south as the current moved along the coast and out of the cove (see figures # 10 & 11). This pattern of lower salinity and higher bacterial concentration at stations 1, 3, and 7 was very consistent throughout the term of the study. Salinity values and bacterial densities to the north at stations 2, 3, and 4 showed the same pattern, but with higher salinity and lower bacteria levels.

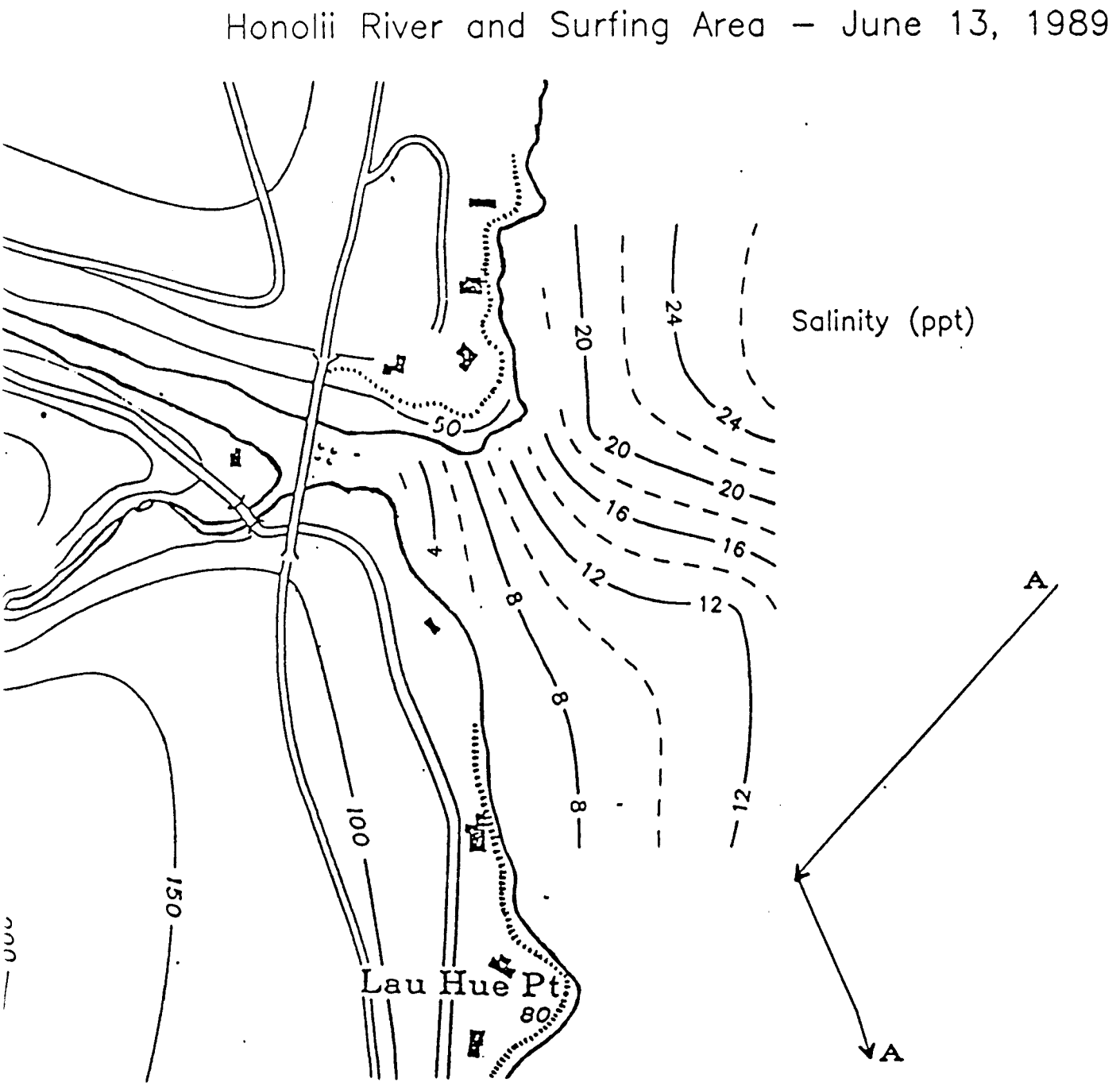
Drogues tracks are included on the salinity and fecal coliform isoline maps for the days sampled and are indicated by lines and arrows. Drogue track data has shown that the offshore surface current patterns in the reach of Hilo Bay and Honolii are complex, but the movement patterns effect the eddying of Honolii Stream as it leaves the confines of the cove. The stream is subject to flow rate variation based on the previous 24 hr. rainfall and runoff that also complicate the overall circulation patterns within the cove.

Figure #8



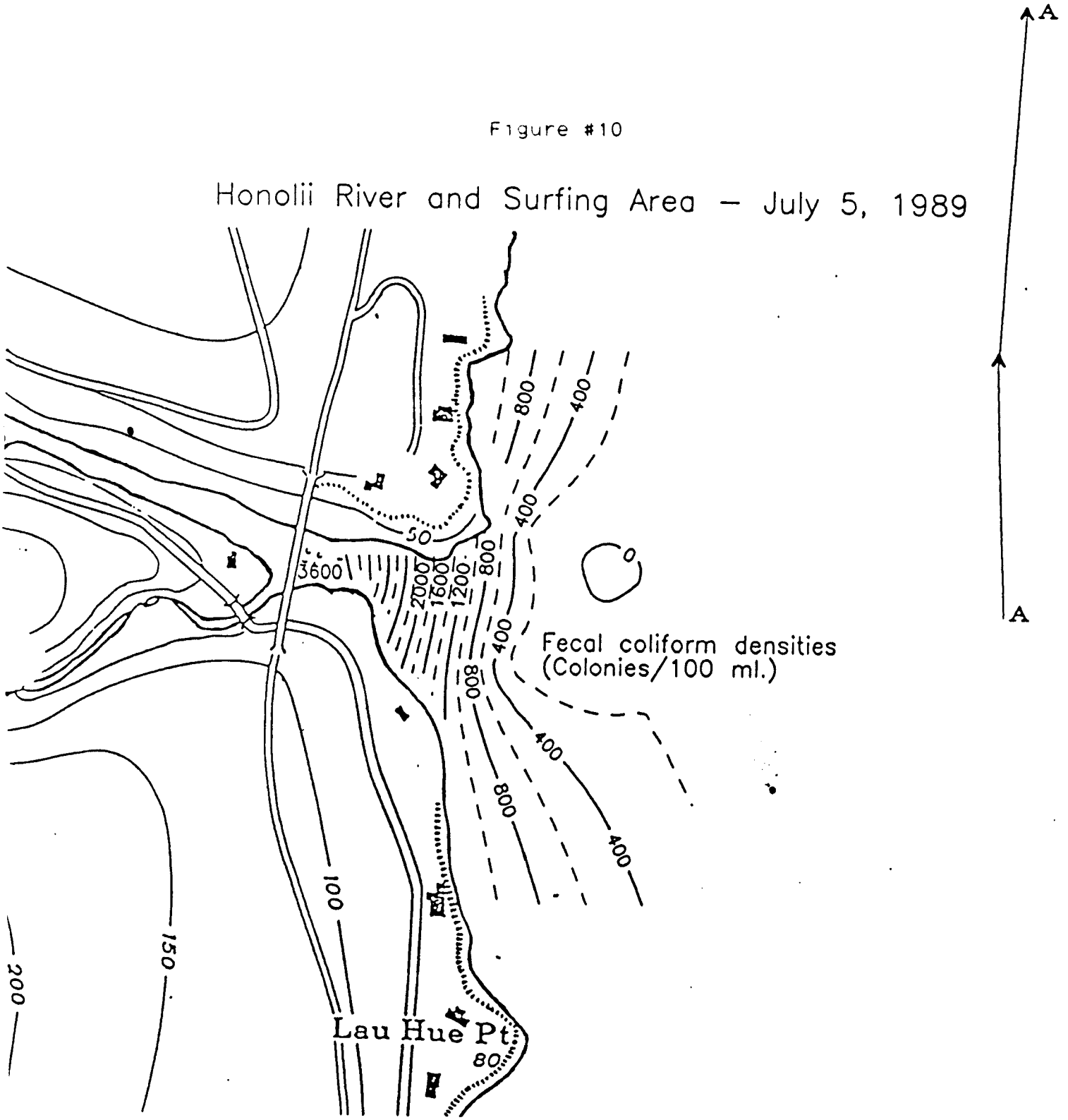
Map of Honolii Beach Park showing fecal coliform bacterial densities for June 13, 1989. Densities are contoured on a contour interval of 50 colonies. The track of surface drogue "A" is also shown.

Figure #9



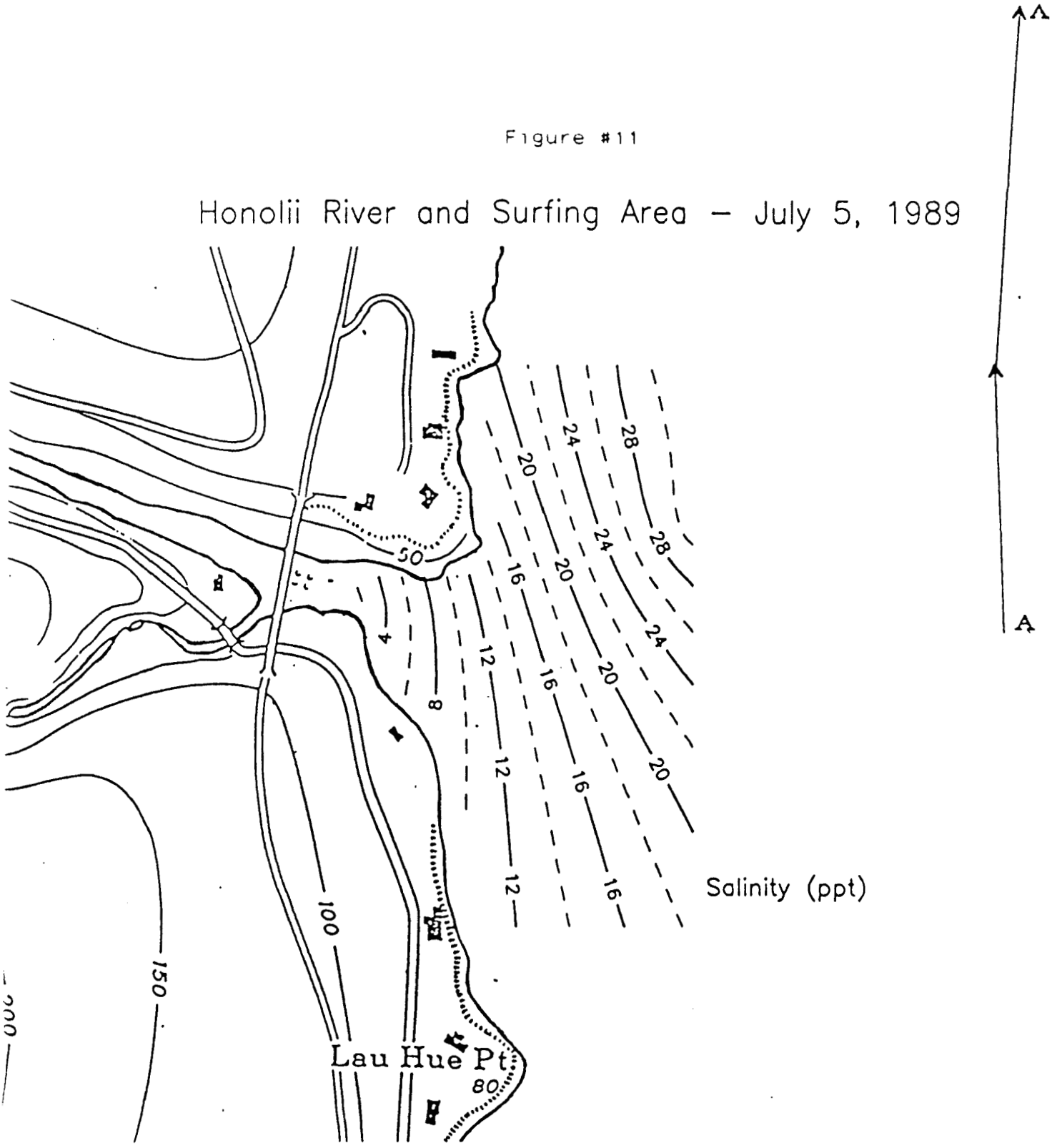
Map of Honolii Beach Park showing surface salinity values for June 13, 1989. The contour interval is 2 parts per thousand. The track of surface drogue "A" is also shown.

Figure #10



Map of Honolii Beach Park showing fecal coliform bacterial densities for July 5, 1989. Densities are contoured on a contour interval of 200 colonies. The track of surface drogue "A" is also shown.

Figure #11



Map of Honolii Beach Park showing surface salinity values for July 5, 1989. The contour interval is 2 parts per thousand. The track of surface drogue "A" is also shown.

Subsurface current, monitored by the Aandera R.M.-7 current meter was generally on a west to north - westerly heading on the days monitored (see figure # 12 for table of deployments). The surface currents (drogue tracks) only correspond to this direction on July 5. The surface current direction on June 1 is northerly but on that day the Aandera could not deployed.

Obviously much more study of the complex interaction between the stream, waves, and ocean current dynamics is needed before more solid conclusions can be drawn about the overall current dynamics within the Honolii Cove and the reach of Hilo Bay.

Figure #12, Table of Deployments

SUMMARY OF 1989 CURRENT METER DEPLOYMENTS

NO	DATE	POSITION		TIMES		DEPLOYMENT	REF. TIDE		IN at	OUT at	CURRENT VECTORS		
		N-coord	W-coord	IN	OUT	duration	type	time	tide state	tide state	TIDE INTERVAL	SPEED	DIRECTION
1	04/08/89	283	293	11:04	12:04	01:00	L	11:00	L	L+1	L to L+1	7.1	268
2	05/23/89	236	309	09:47	11:44	01:57	L	10:28	L-0.7	L+1.3	L-0.7 to L	5.3	240
											L to L+1	1.4	249
3	05/24/89	242	283	09:21	11:00	01:39	L	11:11	L-1.6	L-0.2	L-1.6 to L-1	3.7	28
											L-1 to L-0.2	2.0	276
4	05/30/89	243	294	09:12	10:51	01:39	H	13:25	H-4.2	H-2.5	H-4 to H-3	4.0	61
											H-3 to H-2.5	1.5	81
5	06/13/89	444	426	09:32	11:51	02:19	H	13:11	H-3.6	H-1.3	H-3.5 to H-3	2.7	259
											H-3 to H-2	2.9	253
											H-2 to H-1.3	3.1	246
6	07/05/89	440	442	09:35	10:47	01:12	L	10:22	L-0.8	L+0.4	L-0.8 to L	4.3	248
											L to L+0.4	3.8	334
7	07/10/89	461	448	09:38	11:11	01:33	H	10:43	H-1.1	H+0.5	H-1 to H	8.1	11
											H to H+0.5	9.4	31
8	07/11/89	225	372	09:27	11:24	01:57	H	11:43	H-2.3	H-0.3	H-2.3 to H-2	5.4	224
											H-2 to H-1	5.8	216
											H-1 to H-0.3	4.7	215
9	09/09/89	270	209	11:44	14:34	02:50	L	12:59	L-1.2	L+1.6	L-2 to L-1	4.0	255
											L-1 to L	2.9	232
											L to L+1	2.4	235
											L+1 to L+2	2.9	242
10	10/24/89	236	207	10:54	13:44	02:50	L	10:09	L+0.8	L+3.6	L+0.8 to L+1	3.1	45
											L+1 to L+2	3.9	71
											L+2 to L+3	3.5	66
											L+3 to L+3.6	3.2	84
11	11/18/89	309	408	10:45	15:21	04:36	L	15:28	L-4.7	L-0.1	L-4.5 to L-4	5.8	5
											L-4 to L-3	5.4	6
											L-3 to L-2	5.2	357
											L-2 to L-1	4.3	116
											L-1 to L	4.8	115
12	12/09/89	145	316	10:35	15:05	04:30	H	11:57	H-1.4	H+3.1	H-1.3 to H-1	11.5	182
											H-1 to H	9.8	279
											H to H+1	8.9	47
											H+1 to H+2	7.4	53
											H+2 to H+3	6.5	61

DISCUSSION

It is hypothesized that surface runoff generated in the watershed surrounding Honolii, combined with subsurface percolation through porous lava substrates is concentrating in the stream. This subsurface hydrology is surmised to be flushing numerous cesspools into the drainage area while the normal surface runoff is contributing bacteria from feral and domestic animal sources. This short term study has shown that the concentrations of sewage related bacteria found at the Honolii Stream mouth are carried into the highly used surfing area through the combined effects of rain generated stream flow,mass transport via ocean swells, and the longshore current system. During the period of the study patterns of dispersal followed a southerly route as the stream entered the cove and moved with the longshore current toward Hilo Bay. The current was traced by lower salinity readings to the south of the stream mouth marking the fresh water movement as it left the cove. Bacterial densities follow this current and are diluted as they are transported in the longshore current system. During periods of high rainfall in the previous 24 hrs. the concentrations in the stream and cove are high enough to pose a potential threat to public health. As these bacteria enter the cove densities decrease dramatically do to the combined effects of mass transport, longshore current system, and breaking waves that mix and dilute the concentrations found in the stream. The two bacteria are both reduced at approximately the same rate as they

travel into the cove, but often are still found at high enough concentrations to pose a health hazard to aquatic recreationalists near station #3 (see figures # 13 and #14 for individual station count ranges).

The bacterial pollution threat to Honolii deserves more detailed study if it is to be fully understood and remedied. Source data need to be gathered from a series of upstream stations, dye tests may need to be initiated to check cesspools close to or in the park, epidemiological surveys may need to be done, and a more intensive plume study within the cove may need to be undertaken to better understand the patterns of nearshore current there.

Honolii is a valuable recreational and cultural natural resource that must be protected for future generations. It is hoped that the preliminary data gathered during the course of this study can be used to begin that protection process.

Figure #13, Station Count Ranges, Fecal Coliform

Fecal coliforms per 100 ml of water from seven stations at Honolii Beach Park (n = number of sample-days, % > 400 = percent of sample days registering coliform densities greater than 400 bacteria per 100 ml of water). Station #1 was at the Honolii Stream shoreline near its mouth; stations #2-7 were located within 300 m (1000 ft) of shore and the stream's mouth. Samples were taken from May through July 1989.

Site	n	Geo. mean	Range	% > 400
Honolii #1	7	547	79 - 3790	71.4
Honolii #2	7	55	11 - 170	0
Honolii #3	7	70	14 - 280	0
Honolii #4	6	38	10 - 170	0
Honolii #5	7	45	12 - 120	0
Honolii #6	6	90	21 - 198	0
Honolii #7	7	69	22 - 380	0

Figure #14, Station Count Ranges, Fecal Strep

Fecal streptococci per 100 ml of water from seven stations at Honolii Beach Park (n = number of sample-days). Station #1 was at the Honolii Stream shoreline near its mouth; stations #2-7 were located within 300 m (1000 ft) of shore and the stream's mouth. Samples were taken from May through July 1989.

Site	n	Geo. mean	Range
Honolii #1	6	224	35 - 1720
Honolii #2	7	15	1 - 70
Honolii #3	7	50	11 - 1380
Honolii #4	6	7	0 - 78
Honolii #5	7	12	1 - 100
Honolii #6	6	21	8 - 660
Honolii #7	7	16	1 - 280